International Journal of Agricultural
Science and Research (IJASR)
ISSN(P): 2250-0057; ISSN(E): 2321-0087
Vol. 8, Issue 5, Oct 2018, 61-66

TRANS STELLAR
•Journal Publications •Research Consultancy

NATURE OF SENESCENCE IN SIX POPULAR RICE VARIETIES OF ANDHRA PRADESH

VENKATA NARAYANA. P[1], SREEKANTH. B[2], ASHOKA RANI. Y[3] & KRISHNAVENI. B[4]

[1]*Student, Department of Crop Physiology, ANGRAU, Bapatla, Andhra Pradesh, India*

[2]*Assistant Professor, Department of Crop Physiology, ANGRAU, Bapatla, Andhra Pradesh, India*

[3]*Professor & Head, Department of Crop Physiology, ANGRAU, Bapatla, Andhra Pradesh, India*

[4]*Scientist, Department of Genetics and Plant Breeding, ARS, Bapatla, Andhra Pradesh, India*

ABSTRACT

The objective of this work was to evaluate the pattern of senescence in six popular rice varieties MTU-1001, MTU-1010, MTU-7029, BPT-2231, BPT-3291 and BPT-5204 of Andhra Pradesh. Changes in the chlorophyll content, antioxidant enzymes like Superoxide dismutase (SOD), Catalase (CAT) and Ascorbate Peroxidase (APOX) activities have been investigated in top three leaves after anthesis. Leaf senescence has been expressed as the loss of chlorophyll and decline of antioxidant enzyme activities. The degradation of chlorophyll content and antioxidant enzyme activities in six varieties were high in third leaf than second and flag leaves. This study showed that six varieties belong to sequential mode of senescence that follows an age related pattern in which third leaves senesced earlier than second and flag leaves.

KEYWORDS: Rice, Senescence, Antioxidant Enzymes, Chlorophyll & Anthesis

Received: Jul 25, 2018; **Accepted:** Aug 16, 2018; **Published:** Sep 22, 2018; **Paper Id.:** IJASROCT20189

Original Article

INTRODUCTION

Senescence is generally considered as the terminal phase of the development of the organism, the organ, the tissues or the cells with a series of physiological and metabolic changes leading to cellular disassembly and finally death. Mode of the senescence of leaves in rice found were sequential and non-sequential senescence. In sequential mode, leaves senesce from base to tip of the plant, in sequence from older leaf to younger leaf. Whereas in non sequential mode, younger flag leaves senesce earlier than the older lower leaves. With advancing reproductive development, cv Masuri showed sequential senescence of leaves (Mondal and Choudhuri, 1984). Sequential senescence involves leaf senescence in which flag leaves are the latest to undergo senescence (Shi *et al.*, 2016).

Chlorophyll content was used to monitor the flag leaf senescence in rice (Liu *et al.*, 2010). The loss of chlorophyll with senescence was the commonly observed sign in wheat (Camp *et al.*, 1982 and Midla *et al.*, 1987) rice (Falqueto *et al.*, 2009). Reduction of leaf chlorophyll levels was noticed from anthesis to 25 Days after anthesis (DAA) in rice (Abdelkhalik *et al.*, 2005). Reduction in activity of SOD, APOX and CAT were observed during progression of leaf senescence in rice (Panda and Sarkar, 2013). The activities of SOD declined more quickly in the late stages of grain filling of Proso millet (Dai *et al.*, 2012). Declined catalase activity was noticed in leaves of maize and sorghum during senescence (Patra *et al.*, 1978). Decreased APOX activity was identified in flag and subsequent leaves during the senescence process in rice (Mattagajasingh and Kar, 1988).

MATERIALS AND METHODS

The experiment was conducted during *kharif*, 2017 as a field experiment in field No.49 of Southern Block at Agricultural College Farm, Bapatla, Guntur district, Andhra Pradesh. Six rice cultivars were chosen for this experiment. The seed material of MTU varieties MTU-1001, MTU-1010 and MTU-7029 was procured from Andhra Pradesh Rice Research Institute (APRRI), Maruteru and BPT varieties BPT-2231, BPT-3291 and BPT-5204 from Rice Research unit, Bapatla. Randomized block design was adopted with six rice cultivars as treatments, each replicated four times.

Plant samples were collected destructively from anthesis onwards till harvesting at weekly intervals. From each plot 5 hills are pulled out and top three leaves, were separated from main culm of each hill and immediately placed in ice box. The plant samples transferred immediately to the defreeze conditions in the laboratory for further analysis.

Chlorophyll Content

Total chlorophyll content in top three leaves was estimated using Acetone extraction method Arnon (1949)

Total chlorophyll content in milligrams per gram Fresh weight (mg g^{-1} FWT)

$= [A_{652} \times 1000/34.5] \times [V/1000 \times W]$

Where

A_{652} = Absorbance at 652 nm.

V =Final volume of chlorophyll extract made with 80% acetone (ml).

W = Fresh weight of leaf taken for extraction (g).

Antioxidant Enzymes

Superoxide dismutase activity in top three leaves was determined by following the method as described by Dhindsa *et al*. (1981). To measure SOD activity 0.2 g leaf sample was homogenized in 10 ml of 0.5M phosphate buffer containing 1%NEDD (1-napthyl ethylene diamine dihydrochloride). The homogenate was centrifuged at 4^0 C for 30 min at 10000 rpm (Revolutions per minute) and the supernatant was used for enzyme activity assay. The activity of CAT was determined according to the method of Aebi (1983). APOX activity was estimated according to the method of Nakano and Asada (1981).

RESULTS AND DISCUSSIONS

Table 1: Chlorophyll Content (mg g^{-1}) of Top Three Leaves of Rice Cultivars after Anthesis

Days after Anthesis	Leaf Position from Top	MTU-1001	MTU-1010	MTU-7029	BPT-2231	BPT-3291	BPT-5204	SEm ±	CD (0.05)	CV %
7 DAA	1st	3.861	3.477	3.589	3.688	3.823	3.592	0.086	0.261	4.72
	2nd	3.558	3.252	3.153	3.191	3.352	3.116	0.093	0.281	5.71
	3rd	3.176	2.928	2.64	2.797	3.215	2.711	0.084	0.255	5.81
14 DAA	1st	3.106	2.783	2.803	2.781	3.113	2.641	0.068	0.207	4.80
	2nd	2.572	2.23	2.272	2.268	2.532	2.363	0.054	0.164	4.58
	3rd	2.192	1.976	1.927	1.922	2.059	1.856	0.058	0.177	5.92
21 DAA	1st	2.058	1.801	1.857	1.81	1.945	1.812	0.042	0.127	4.50

	2nd	1.466	1.366	1.358	1.265	1.364	1.244	0.054	0.163	8.06
	3rd	1.081	0.907	0.926	0.965	0.995	0.844	0.045	0.136	9.47
28 DAA	1st	1.104	1.023	0.991	0.963	1.024	0.989	0.049	N. S	9.65
	2nd	0.565	0.517	0.465	0.472	0.546	0.541	0.0192	0.057	7.40
	3rd	0.190	0.188	0.171	0.170	0.199	0.181	0.009	0.028	10.18

Table 1 shows the changes in chlorophyll content of the flag, second and third leaves of six rice cultivars with progress of reproductive development. In six rice cultivars, the flag leaf showed higher chlorophyll content than the second and third leaf during leaf senescence, indicating that the third leaf senesced earlier than second and first leaf, which can characterize as sequential leaf senescence. The percent degradation in chlorophyll content was higher in third leaf (94.0%) followed by second (83-85%) and flag leaf (71-73%). Falqueto *et al.* (2009) stated that chlorophyll loss and yellowing of leaves in rice are convenient and distinctive indicators of leaf senescence. In most of cereal crops like wheat, rice and barley, the senescence of leaves begins with that of basal leaf (Song heng *et al.*, 2004). Chlorophyll declined during senescence phase in all top three leaves of rice (Zhang *et al.*, 2003).

Table 2: Superoxide Dismutase Activity (Unit g^{-1} FWT min^{-1}) in Top Three Leaves of Rice Cultivars after Anthesis

Days after Anthesis	Leaf Position from Top	MTU -1001	MTU -1010	MTU -7029	BPT-2231	BPT-3291	BPT-5204	SEm (±)	CD (0.05)	CV %
7 DAA	1st	184.3	178.0	164.8	177.8	162.5	171.3	4.1	12.4	4.8
	2nd	164.5	165.8	151.0	168.0	163.3	154.5	4.3	N. S	5.3
	3rd	154.5	156.3	142.3	159.0	156.0	140.8	3.8	11.5	5.0
14 DAA	1st	133.3	129.8	119.3	126.0	120.0	131.0	3.0	8.9	4.7
	2nd	119.0	112.0	108.0	113.0	105.0	101.0	3.6	10.7	6.5
	3rd	89.5	82.0	82.5	87.0	83.0	91.8	2.0	6.0	4.6
21 DAA	1st	90.0	80.8	81.8	86.5	79.0	81.0	2.5	7.4	5.9
	2nd	74.5	62.8	68.3	73.3	75.0	63.3	1.9	5.8	5.5
	3rd	63.8	53.0	54.0	55.5	55.3	57.8	2.8	N. S	9.7
28 DAA	1st	45.5	39.3	40.3	42.3	39.0	42.8	1.6	N. S	7.6
	2nd	31.5	29.0	24.0	27.5	32.8	29.5	1.6	5.0	11.4
	3rd	25.8	20.5	19.8	22.8	19.5	26.3	1.3	4.0	11.8

(Refer to Table 2) Six rice Cultivars exhibited significant variation in SOD activity leaf wise and stage wise from anthesis to maturity. Maximum level of SOD activity in top three leaves existed at 7 DAA, decreased with increase in DAA. The reduction in SOD activity from 7 to 28 DAA was 75 to 78% in flag, 80 to 84% in second and 81 to 88% in third leaves. The decline in flag leaf was less in MTU-1001, BPT-5204 and more in MTU-1010. In second leaf, less in BPT-3291 and more in MTU-7029. In third leaf, less in BPT-5204, MTU-1001 and more in BPT-3291 and MTU-1010. Dai *et al.* (2012) reported that SOD activity decreased quickly in late stages of grain filling of proso millet. Mattagajasingh and Kar (1988) stated that in flag and following leaves of rice, SOD activity decreased after anthesis.

Table 3: Catalase Activity (Unit g^{-1} FWT min^{-1}) in Top Three Leaves of Rice Cultivars after Anthesis

Days after Anthesis	Leaf Position from Top	MTU -1001	MTU -1010	MTU -7029	BPT-2231	BPT-3291	BPT-5204	SEM (±)	CD (0.05)	CV %
7 DAA	1st	156.8	150.5	145	151.8	136.8	142.5	3.3	9.8	4.4
	2nd	128.3	141.8	131.3	138.5	133	130.5	3.4	N. S	5
	3rd	121	127.8	119.3	128.5	121.5	118.8	2.8	N. S	4.6
14 DAA	1st	118.5	119.5	115	125.8	113.8	116	2.5	7.4	4.2
	2nd	85.5	80.5	81	87.5	79.3	70.5	2.8	8.6	7
	3rd	68	69.5	72.3	79.8	70.8	72	2.4	N. S	6.7

Table 3: Contd.,										
21 DAA	1st	72.5	66.5	67.3	81.5	68.5	63.5	2.5	7.5	7.2
	2nd	53	55	50.3	57	57.3	53	2.2	N. S	8.1
	3rd	44	45.8	45.3	54.3	46.3	43	2.1	6.3	9
28 DAA	1st	41.3	36.3	36.8	46.8	36	33.8	2.1	6.3	10.9
	2nd	30	33	30	32.5	27	26.3	1.2	3.5	7.9
	3rd	25.5	21.8	21.3	23	25.8	23.8	1.3	N. S	10.7

Table 3 confirms that flag leaf had the highest CAT activity followed by second and third leaf. Cultivar variation in CAT activity of flag leaf existed starting from anthesis to maturity, second leaf was seen only at 14 and 28 DAA and third leaf at 21 DAA. The decrease in CAT activity from 7 to 28 DAA was 69 to 76% in flag, 77 to 80 % in second leaf and 78 to 83% in third leaves. The decline in flag leaf was less in BPT-2231 and more in BPT-5204, MTU-1010. In second leaf more in BPT-5204, BPT-3291 and less in other four cultivars. In third leaf less in BPT-3291, MTU-1001 and more in MTU-7029. Declined catalase activity in rice leaves during senescence was reported by Biswa and Choudhuri (1980). Mondal and Choudhuri (1984) observed the lowest CAT activity in the third leaf followed by second and flag leaves of rice cultivar measure and they characterized it as sequential senescence. Declined catalase activity was observed in leaves of maize and sorghum during progression of senescence (Patra *et al*.1978). Similar results were reported by Khan and Choudhuri, (1988) and Prochazkova *et al.* (2001) in maize; Causin *et al*.(2015) in wheat and Dai *et al.* (2012) in foxtail millet. The current results in rice leaves agree with the findings in rice by Panda and Sarkar (2013).

Table 4: Ascorbate Peroxidase Activity (unit g^{-1} FWT min^{-1}) in Top Three Leaves of Rice Cultivars after Anthesis

Days after Anthesis	Leaf Position from Top	MTU -1001	MTU-1010	MTU-7029	BPT-2231	BPT-3291	BPT-5204	SEm ±	CD (0.05)	CV %
7 DAA	1st	497.5	434.8	418.1	466.7	437.3	426.3	4.3	13.0	1.9
	2nd	446.9	425.5	369.6	405.7	400.5	389.4	7.0	21.0	3.4
	3rd	401.6	378.9	363.6	383.9	375.2	352.0	5.8	17.5	3.1
14 DAA	1st	371.5	345.3	312.3	364.8	346.7	337.5	5.4	16.3	3.1
	2nd	338.1	297.8	282.8	332.2	305.0	301.9	5.6	16.9	3.6
	3rd	307.0	256.0	251.3	280.4	285.0	258.8	6.2	18.6	4.5
21 DAA	1st	282.1	228.2	193.9	260.3	221.6	214.8	5.7	17.1	4.9
	2nd	224.6	207.3	166.0	224.7	191.6	178.1	6.4	19.4	6.5
	3rd	194.9	162.0	143.8	200.5	163.4	146.5	7.0	21.1	8.3
28 DAA	1st	164.1	136.7	151.8	166.3	138.3	125.9	4.7	14.0	6.3
	2nd	128.6	105.8	128.6	134.6	113.5	108.6	5.1	15.3	8.5
	3rd	103.5	89.4	103.6	106.4	96.4	88.4	3.7	11.3	7.6

Table 4 shows Ascorbate peroxidase (APOX) activity in top three leaves of rice cultivars differed significantly at all days of observations. The decline in APOX activity was 64 to 71, 65 to 75 and 72 to 75 per cent in flag, second and third leaf, respectively. In the present study it was noticed that APOX activity declined in top three leaves during progression of senescence from 7 to 28 DAA. Flag leaf of all cultivars had the highest APOX activity followed by second and third leaves. The decline in flag leaf was more in MTU-1001 and less in BPT-2231. In second leaf, less in BPT-2231 and more in BPT-5204. In third leaf less in BPT-2231 and more in MTU-7029, BPT-5204. Decreased APOX activity in flag and following leaves during the senescence was reported in rice (Mattagajasingh and Kar, 1988 and Panda and Sarkar, 2013) and Prochazkova *et al*.(2001) in maize.

CONCLUSIONS

The per cent degradation of chlorophyll content and antioxidant enzyme activities in six cultivars was more in third leaf than second and flag leaf, which can be characterized as sequential leaf senescence.

REFERENCES

1. *Abdelkhalik, A. F., Shishido, R., Nomura, K and Ikehashi, H. 2005. QTL-based analysis of leaf senescence in an indica / japonica hybrid in rice (Oryza sativa L.). Theoritaical and Applied Genetics. 110(7): 1226 –1235.*
2. *Aebi, H. 1983. Catalase. Methods of enzymatic analysis. 2: 673-684.*
3. *Arnon, D. I. 1949. Copper enzymes in isolated chloroplasts. Polyphenoloxidase in Beta vulgaris. Plant Physiology. 24(1): 1-15.*
4. *Biswas, A. K and Choudhuri, M. A. 1980. Mechanism of monocarpic senescence in rice. Plant Physiology. 65 (2): 340-345.*
5. *Camp, P. J., Huber, S. C., Burke, J. J and Moreland, D. E. 1982. Biochemical changes that occur during senescence of wheat leaves: I. Basis for the reduction of photosynthesis. Plant Physiology. 70(6): 1641-1646.*
6. *Causin, H. F., Marchetti, C. F., Pena, L. B., Gallego, S. M and Barneix, A. J. 2015. Down-regulation of catalase activity contributes to senescence induction in wheat leaves exposed to shading stress. Biologia Plantarum. 59(1): 154-162.*
7. *Dai, H. P., Shan, C. J., Wei, A. Z., Yang, T., Sa, W. Q and Feng, B. L. 2012. Leaf senescence and photosynthesis in foxtail millet (Setaria italica L. P. Beauv) varieties exposed to drought conditions. Australian Journal of Crop Science. 6 (2): 232.*
8. *Dhindsa, R. A., Dhindsa, P. P and Thorpe, T. A. 1981. Leaf senescence correlated with increased permeability and lipid peroxidation and decreased levels of superoxide dismutase and catalase. Journal of Experimental Botany. 126: 93-101.*
9. *Falqueto, A. R., Cassol, D., Magalhaes Junior, A. M. D., Oliveira, A. C. D and Bacarin, M. A. 2009. Physiological analysis of leaf senescence of two rice cultivars with different yield potential. Pesquisa Agropecuaria Brasileira. 44(7): 695-700.*
10. *Low, V. I. Effect Of Seed Priming On Germination And Vigour In Low And High Longevity Rice Genotypes.*
11. *Khan, R. I and Choudhuri, M. A. 1988. Changes in enzyme activities related to hydrogen peroxide metabolism during senescence of wheat plant. Indian Journal of Plant Physiology. 31(1): 97-101.*
12. *Liu, L., Zhou, Y., Szczerba, M. W., Li, X and Lin, Y. 2010. Identification and application of a rice senescence-associated promoter. Plant physiology. 153(3): 1239-1249.*
13. *Mattagajasingh, S. N and Kar, M. 1988. Correlative changes in the antioxidant system and lipid peroxidation of rice leaves during monocarpic senescence. Plant Science Research. 10: 36- 41.*
14. *Midla, H., Padu, E., Kolk, U and Soosaar, A. 1987. Biochemical changes in primary wheat leaves during growth and senescence. Biology Plantarum.29: 445.*
15. *Mondal, W. A and Choudhuri, M. A. 1984. Sequential and non sequential pattern of monocarpic senescence in two rice cultivars. Physiologia Plantarum. 61 (2): 287-292.*
16. *Nakano, Y and Asada, K. 1981. Hydrogen peroxide is scavenged by ascorbate-specific peroxidase in spinach chloroplasts. Plant and Cell Physiology. 22(5): 867-880.*
17. *Panda, D and Sarkar, R. K. 2013. Natural leaf senescence: probed by chlorophyll fluorescence, CO_2 photosynthetic rate and antioxidant enzyme activities during grain filling in different rice cultivars. Physiology and Molecular Biology of Plants. 19(1): 43-51.*

18. *Patra, H., Kar, M and Mishra. 1978. Catalase activity in leaves and cotyledons during plant development and senescence. Biochemie und Physiolgie der Pflanzen. 172: 385-390.*

19. *Prochazkova, D., Sairam, R. K., Srivastava, G. C and Singh, D. V. 2001. Oxidative stress and antioxidant activity as the basis of senescence in maize leaves. Plant Science. 161: 765 -771.*

20. *Shi, H., Wang, B., Yang, P., Li, Y and Miao, F. 2016. Differences in sugar accumulation and mobilization between sequential and non-sequential senescence wheat cultivars under natural and drought conditions. Public Library of Sciences. 11 (11): 0166155.*

21. *Songheng, J., Dean, J., Pinmei, W., Kai, Z and Xiaoyan, W. 2004. Characteristics of gas exchange and chlorophyll fluorescence in different position leaves at booting stage in rice plants. Zhongguo Shuidao Kexue. 18(5). 443- 448.*

22. *Zhang, C., Peng, S and Laza, R. C. 2003. Senescence of top three leaves in field-grown rice plants. Journal of Plant Nutrition. 26(12). 2453-2468.*